APPENDIX B

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The Development and Application of the C Scale

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The C Scale: A Scale for Measuring Constructive Effort in Think Aloud Protocols

In this paper, attempts to develop a scale to measure constructive effort are described, the application of the *C Scale* to a data set is reported[1], and the results are discussed. Modifications and future directions for this scale are then suggested. Initially, some theoretical issues are addressed, including the purpose and requirements of this scale, and some of the methodological considerations pertinent to its development.

The notion of a scale of constructive effort for text processing which is presented in this paper, is theoretically derived from two related areas; first, from the concept of *intentional learning* (Bereiter & Scardamalia, 1985, 1986) and secondly, from analyses of mature and immature text processing strategies (Scardamalia, 1984, Scardamalia & Bereiter, 1982, Scardamalia & Paris, 1985). The relationship of these two areas to a scale of constructive effort has been described generally in some length elsewhere (Joram, 1985) and these concerns will only briefly be touched upon here. This paper focuses on more specific issues, such as the qualities of mature and immature text processing which we would expect to be distinguished by the C Scale on think aloud protocols.

Discussion of General Relationship Between Writing and Constructive Effort

Mental effort is a central element in a definition of intentional learning; "learning is intentional or not according to the amount of mental effort devoted to learning itself, over and above the effort devoted to attaining other goals of the activity" (Bereiter & Scardamalia, 1985, p. 7). According to these authors, intentional learning refers to learning which is "carried out at a high level of constructive effort" (p. 7). How might such constructive effort be evident in the domain of writing? Since Scardamalia, Burtis & Bereiter (in preparation) have pointed out, when speaking of constructive strategies what is referred to is the portion of mental effort which is devoted to meaning construction, it follows that expert writers would be characterized in part, by their continual efforts to create meaning through writing. The distinction between the *knowledge telling* and *knowledge transforming*

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[1]Many thanks to Pamela Paris for the use of her data (which has been collected for her doctoral dissertation), and for her invaluable assistance in developing the scale.

strategies of immature and mature writers (Scardamalia & Bereiter, 1982; Scardamalia, Bereiter & Steinbach, 1984; Scardamalia & Paris, 1985) is important in shaping our conception of what kinds of processes can be taken as indicators of constructive effort.

Knowledge tellers engage in what Scardamalia and Bereiter (1984) refer to as a "think-say" process of writing which procedes by "spreading activation". It is not characterized by the use of goals and plans, or by problem-solving procedures. Knowledge transformers, on the other hand, construct a *problem space* and a *rhetorical space*, and move through both of these abstract spaces during the writing process. Operations in the content space "lead from one state of belief to another", and this is effected through inferring, hypothesizing etc. Operations in the problem space are those which "alter the text, goals, or relations between them" (Scardamalia, Bereiter, & Steinbach, 1984, p. 3).

It seems likely that a mature writer will most often engage in a knowledge transforming style of writing when writing about a topic which they have not often addressed, since, as Flower & Hayes (1980) have expressed, "In such situations, we would expect a good writer to explore the problem afresh and to give conscious time and attention to building a unique representation" (p. 25). It follows, however, that a mature writer may exert less constructive effort if they can rely solely upon automatic procedures which are brought to bear on the task, as in a situation, for example, where they have written on a topic many times (an example of this can be found in graduate school, where some students consistently write papers and give presentations on the same topic year after year. While the products may appear more polished, we might guess that the amount of constructive effort expended decreases, unless the student continually sets new goals and addresses new problems even while maintaining the same theme.) For the purposes of this paper, we will consider a greater amount of constructive effort to be expended in performing problem solving in ill-defined, as opposed to well-defined areas.

It has been suggested that a high degree of constructive effort will be instantiated in text production as the knowledge transforming style of writing, which can be contrasted with a lesser degree of constructive effort manifesting as the knowledge telling style of writing. According to Scardamalia, Burtis & Bereiter (in preparation), "mature text processing strategies require more rather than less mental effort than immature ones". The key element which differentiates these two styles of writing and which is not subject to automatization by experts, is that of meaning construction.

Specific Features of Protocols Which Will Distinguish Levels of Constructive Effort

An immature writer will most likely engage in a knowledge telling style of writing according to previous research on text processing habits (Scardamalia & Bereiter, 1982; Burtis, Bereiter & Scardamalia, 1983; Scardamalia, 1984). We cannot assume that constructive effort is correlated with the age of writers since some young writers may exhibit relatively high degrees of constructive effort as they engage in a rudimentary, emerging form of knowledge transforming. Around the ages of 12 to 14 we begin to see some evidence of conceptual planning and indirect content, but even before students spontaneously articulate their use of procedures, constructive effort may be one of the *engines* behind their performance.

A scale of constructive effort which can be applied to adolescent writers should be sensitive to processes which may be precursors to a more developed style of writing. Some young writers may exhibit varying degrees of constructive effort despite the fact that they are, as yet, unable to engage in the fully developed knowledge transforming style of writing which is characteristic of expert writers. It is crucial, therefore, that the C Scale not base its estimate of the amount of constructive effort on the quality of content, since young writers may expend a considerable amount of constructive effort with few evident gains in text quality. Further research is necessary in order to clarify the nature of the relationship between amount of constructive effort expended and the quality of the resulting text for writers of different ages. As Bereiter and Scardamalia (1983) point out, one can engage in a knowledge telling style of composing and end up with a relatively sophisticated product:

> With sufficient refinements the low-road strategy can achieve writing comparable to most of what people on the high road can produce. (p. 3)

When designing the C Scale, we therefore wish to distinguish as much as possible, effort expended from text quality. A summary follows of the points discussed above:

1. **The C Scale should distinguish degrees of constructive effort as opposed to simply discriminating expert from novice writers. While greater amounts of constructive effort will predictably be found in the think aloud protocols of expert writers, this rated constructive effort should be contingent upon the degree of meaning construction displayed rather than on strategies which are subject to automatization. A way of summarizing the manner in which constructive effort is thought to be manifested in text production is the knowledge telling/knowledge transforming distinction. Writers employing a knowledge transforming style of text production are thought to be engaging in greater amounts of constructive effort, while those following a knowledge telling strategy are predicted to exhibit a lesser degree of constructive effort.**

2. There may be a minimum age at which the present C Scale can be applied (approximately 12 years old) because until that time there may not be enough evidence of explicit knowledge transforming strategies to enable us to distinguish different kinds of writers. Other scales or specially devised tasks might be more appropriate for young subjects. However, there may be enough evidence of implicit mental operations in the generated content to justify using this scale for young subjects (perhaps even younger than those in the present sample).

3. The estimation of constructive effort should not be based on the quality of the generated content but rather on evidence of the effort expended in generating it.

In the previous discussion, certain requirements of this scale have been pointed out and will now be linked with specific features of the scale. A general description of each subscale is presented and followed by an explanation of how particular features of the scale relate to aspects of the theoretical considerations which underly its construction.[2]

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[2]A scale was designed and a set of 16 protocols were scored using this coding scheme, and in the process of scoring them, changes were made to the scale. In keeping with Ericsson & Simon's (1984) caution that one should not develop a scale, score a set of protocols, modify the scale and use this new version to analyze the same set of protocols, I am reporting the version of the scale which was initially developed and used to score this set of 16 protocols. Throughout the paper modifications are suggested and the modified version of the scale is presented at the end of the paper. Time constraints have not permitted me to score another set of protocols as yet using the modified version of the scale.

Description of the C Scale

General Description[3]

The proposed C Scale has three subscales: 1) Implicit Operations Subscale, 2) Explicit Operations Subscale, and 3) Metacomments Subscale. These three subscales will be referred to hereafter by the following abbreviations, respectively the IO, EO, and MC subscales. Each protocol was parsed into a minimal parsible unit, and each unit was scored on one of the three subscales. If there was reference to an explicit operation, the statement was scored on the EO scale. If the statement appeared to be generated content, then it was scored on the IO scale, and if it referred to the text, the writer, or the task, it was scored on the MC scale. After each statement was numbered and scored, these codes were transfered to a scoring sheet and then tabulated for all subjects.

One of the goals in developing this scale was to create a system which would not only result in a list of categories, but which would capture the structure of the protocol as suggested by Bereiter (1985c). Although initially it seemed that this could only be done by relating coded categories to each other, it now seems that some degree of the relationship between different statements can be tapped through the codes which are assigned to them. This was the purpose of the Implicit Operations Subscale. However, it seems that it is still be necessary to carry out contextual analyses on the coded statements in order to get a sense of the structure of the protocol. This might be done by computing the proportion of types of statements in sections of the protocol. Meichenbaum et al. (1985) discuss the analysis of a set of think aloud protocols which consisted of "a sequential probability analysis (i.e., a Markovian chain analysis) of the six categories of verbalization". It would be interesting to perform such an analysis on the data set reported here.

Implicit Operations Subscale[4]

CN, CA, CE -

Since approximately ninety percent of the protocols of young writers are comprised of generated content (Burtis et al., 1983), it would be advantageous to have a subscale which could assess cognitive

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[3] See C Scale at the end of this appendix.

[4] The name for this subscale was formerly *Content Subscale* and was changed at the suggestion of Earl Woodruff. Likewise, the Procedural Subscale became the Explicit Operations Subscale.

operations on the basis of the generated products, i.e. the content. The prime intent behind devising the IO subscale was to distinguish content which has been generated through a knowledge telling strategy from that which has been generated through a knowledge transforming style. Thus, the three categories of "New Content, Content Addition, and Content Elaboration" contain subcategories which are thought to imply that either knowledge telling or knowledge transforming operations have occurred in the generation of content. Subcategories 1, 2, 3, 5 and 6 are thought to involve knowledge telling strategies. Subcategories 4 and 7 on the Elaboration category are hypothesized to be more characteristic of the knowledge transforming style of text production, because they involve the reflection on previously generated text and the subsequent transformation of that text. Knowledge transforming should be evident by the presence of inferences, hypotheses, etc., which "lead from one state of belief to another" (Scardamalia & Bereiter, 1986).

When coding the protocols, it proved difficult to distinguish content which was added from content which was elaborated. Since knowledge tellers elaborate content but do so by referring back to the topic or to the previous sentence (Scardamalia, Bereiter & Steinbach, 1984), it would be useful to designate the basis on which the content is being elaborated. It may also be better to collapse the three categories into two categories of Content and Elaborated Content.

CO - The category of Content Organization is intended to reflect operations which have organized previous text, without the explicit reference to such a procedure by the writer. Thus, this category would be characteristic of knowledge transforming, and would likely not appear frequently in protocols until adolescence.

CR - The category Content Rewording assesses reworded text, that is, text that has been repeated with minor changes, such as the addition of an "s", or the substitution of a word/phrase with little resultant change in meaning (surface and word level revisions in Faigley & Witte's (1981) terms). The two subcategories of CR 1 (Minor) and CR 2 (Paraphrasing), are designed to index the unit of text on which the revision is made. This category could be expanded upon in a future version of the scale in order to distinguish what Faigley & Witte (1981) have termed *surface* and *meaning* level changes. Such an elaboration would be necessary if the scale is to be applied to expert writers at the phase of both draft and revision. Since young writers do not tend to revise their texts very much, the present category and subcategories of Content Rewording were adequate for performing the analyses

reported in the present paper.

CD - Because some of the protocols which were analyzed had been written on computers, and contained frequent rereading, interruptions due to mechanical concerns, and continuations of content generation, it was necessary to adapt the scale to suit this purpose. Since one of the questions addressed in the AWORD study had been the effects of mode of production on the process of writing, an index of these interrruptions and continuations was devised. The CD category therefore contained subcategories: CD 5 (Rereading) and CD 7 (Continuation of statement which was interrupted). Without this last subcategory, one single statement which had been interrupted frequently would have been scored as several incidences of content generation, and this would have resulted in an overinflated estimate of content generation.

Explicit Operations Subscale

This subscale was designed to assess those cognitive operations which have been explicitly mentioned by the student. As Burtis et al. (1983) have reported, less than ten percent of protocols collected from children and adolescents ages 10 to 18 are comprised of conceptual planning. Before adolescence this planning is primarily tied to text content (PL 2 & Pl 4 on the scale) and only later develops into planning which has an indirect bearing on content, such as organizing content (PL 5).

In addition to planning, the C Scale should index what Burtis et al. refer to as *indirect content*, which is a statement of content preceded by a phrase such as "I was thinking that" or "it seems to me that". They are scored on the Explicit Operations subscale (as PC 1, PC 3, PC 4, and PC 6) when there is a phrase which indicates a reference to a cognitive operation such as "I am thinking that". In addition, they are scored on the Implicit Operations subscale as a CN 2, CA 2 or CE 2, when there is a statement such as "I think that". These kinds of statements seem to involve some awareness by the writer of his/her mental state. Research on the development of propositional attitudes (Olson & Astington, 1985; Perner & Wimmer, 1985), suggests that the use of these linguistic forms involve metacognitive awareness of one's own or others' mental states. It is possible that a greater number of these terms might indicate either a more developmentally advanced level, greater literacy skills (as one might suspect for our Enriched subjects), or a greater amount of constructive effort exerted by subjects.

Many of the operations outlined on the Explicit Operations scale can be performed by both

knowledge tellers and knowledge transformers, but it is hypothesized that the frequency of these operations and the pattern of their use will distinguish the various levels of writers. Paris (personal communication, Feb. 1986) has suggested that expert writers will be characterized by a prolonged period of working out the "rhetorical problem space" early in the protocol. We might therefore hypothesize that this would include planning statements, statements which indicate that the writer is thinking about and clarifying their beliefs and procedures, and statements which show evidence that the writer is searching for information in service of these goals. Although we might expect planning to be intermixed throughout composing (Hayes & Flower, 1980), these authors also suggest that translating and editing will predominate the latter portion of protocol. Hence we may see the bulk of the planning, clarifying, and searching statements made in the initial phase of the protocol, and a preponderance of translating, evaluating, and revising comments towards the end. In addition, there may be a difference in the way writers are able to use goals to alter the text.

Metacomments Subscale

This subscale is intended to assess comments made about the text, the author, the task etc., referred to by Scardamalia (1984) as "writers' comments about what they are doing and attempts to keep themselves going" (p. 8).

Evaluation - Based on research in the area of creativity (Wallas, 1926, Patrick, 1935, 1938), it was hypothesized when designing part of the AWORD study, that better writers may delay evaluation of their ideas, text, etc. until the latter phases of text production, and that they would aim these comments at deeper levels of the text than would less skilled writers. For this reason, a large component of the MC subscale is comprised of indices of evaluative comments. These evaluative comments can be distinguished on the scale in terms of the object they are directed towards (text, self, etc.).

Intrinsic/Extrinsic Concerns - The presence of intrinsic concerns may indirectly provide a sense of the presence of different kinds of goals, since as Scardamalia & Bereiter (1982) have suggested, good writers subsume external goals under internal ones (p. 169). Several subcategories of the Metacomments subscale can provide indications of the writer's expression of intrinsic/extrinsic concerns: MD 1 - Direct response/question to experimenter; and the assigning of Self, Other, or General on the MT category.

The ME Category might tell us how the writer manages an aspect of the writing process, that of revision. The expert writers in Paris' sample seemed to be able to override their own negative evaluations, and to delay evaluation and revision. Some writers in our sample would make negative comments about what they were doing or material they generated, and the effects of these comments on text production remains to be examined. An analysis of these comments might indicate varying frequencies and patterns of occurrence. It would be of interest to note, for example, if switching to a new theme in the course of composing is usually preceded by particular kinds of evaluations of generated text.

Application of the Scale

Experimental Design for Collection of Protocols

The C Scale was used to score 16 think aloud protocols which had been generated by eight Grade 8 students while they composed two drafts, which they later revised. In one condition, *No-edit*, the writers were not allowed to edit their texts, while in the other condition, *Edit*, they were permitted to do so. Half the subjects wrote both drafts on an ICON computer and half the subjects composed using paper and pencil. Half the subjects were *Enriched* writers, designated as such on the basis of teacher recommendations, and the other half were *Average* writers. Analyses of the students' English grades and Reading Comprehension scores on the Canadian Test of Basic Skills corroborated the teachers' classification. Thus, Instructions (Edit/No-edit) was a within subjects factor, and Mode and Skill (Computer/Paper & Pencil; Average/Enriched) were between subjects factors.

Students wrote their drafts on two topics:

1. "So for people in the future... "
2. "So, as you can see, things would really be different if there were no..."

Students were told to use these sentences to end their compositions, since research by Scardamalia & Bereiter has suggested that this form of procedural facilitation "can enhance the use of goals in immature writers".

The design of the study, for the subset of subjects used for this paper, was as follows:

Experimental Design for One Ability Group

Subject #	Draft 1	Draft 2
E3	No-edit Computer	Edit Computer
E4	Edit Computer	No-edit Computer
E11	No-edit P&P	Edit P&P
E12	Edit P&P	No-edit P&P

Because the C Scale was used to score these protocols, it was necessary to consider Mode of Production, Skill and Instructions as factors. Previous analyses of these protocols had been carried out with a different coding scheme which overlapped very little with the present one. In addition, product measures of the texts had previously been performed by two judges who rated texts on the following dimensions: holistic, technical correctness, style and creativity. Very roughly, the findings from these previous analyses (see Table 4) were that Average students performed best while in the Edit condition using paper and pencil, while the Enriched students wrote their best texts in the No-edit condition on the computer (significant differences were found in the proportion of *High level* planning statements to the total number of planning statements, and on the Creativity product ratings).

Previous research which has examined mode of production on the writing process (Scardamalia, Bereiter & Goelman, 1982) found that although students produced longer texts when freed from mechanical concerns (using a dicta-phone), there were no differences in rated text quality as a function of mode of production. Although the present study allows for further investigation into the question of mode effects on writing, it is only of concern here in so far as it relates to the factors of Skill and Instructions.

Another issue of interest, is the instructions which the subjects in the No-edit condition received, that is, to refrain from being concerned with the correctness of their texts. In the No-edit condition, students were told not to worry about making errors as they would have time later to correct their

mistakes. Scardamalia (1984) has pointed out several problems with these kinds of *free-writing* instructions (Elbow, 1983). First, she suggests that children will not necessarily be able to follow these instructions, and that "concerns with mechanics are not the major impediment to presentations of coherent ideas in discourse" (p. 900). Secondly, Scardamalia (1984) and Scardamalia & Bereiter (1983) have pointed out that by removing concerns for correctness, students do not learn how to coordinate ideas or different aspects of the task at the same time. The present design allowed for an empirical examination of this issue.

Results

Results for the Implicit Operations Subscale

The results which are presented in this paper are mainly for the Implicit Operations Subscale, because the greatest number of statements in the protocols of these adolescent subjects were coded on this subscale. Thus, it was perceived as being the most stable indicator of constructive effort.

Scores were totalled for each subject, and these data are presented in Table 1. Two indices were generated from this scale, both exploratory in nature. The first was the C Score, which was calculated in the following way:

1. Count the number of:
    a. CN + CE 1-3
    b. CE 1-3
    c. CN + CA 4
    d. CE 5,6
    e. CE 4,7
2. Multiply each subtotal by a weight:
    a. Total (CN + CE 1-3) by 1
    b. Total (CE 1-3) by 2
    c. Total (CN + CA 4) by 3
    d. Total (CE 5,6) by 3
    e. Total (CE 4,7) by 10
3. Add these multiplied numbers together and divide by 10.

C Scores were calculated for each subject and are presented in Table 2. Informal analyses of the data (see Table 3) yielded results which are consistent with the general pattern which has e nerged from previous examinations of the process and product measures.

Average C Scores were computed for the Enriched and Average subjects (averaging all subjects' scores) and they were respectively, 6.05 and 4.25. Since the Enriched students were superior to the Average students in the domain of text processing, we would expect the C Score to reflect this difference.

It is interesting to note that in the small boxes on the right hand side of Table 3, where the C Scores have been collapsed to show the effects of editing and mode of production, both Enriched and Average students obtain approximately the same C Scores when writing with paper and pencil, in the Free-edit condition. However, when their normal performance is disrupted by the computer and by the instructions not to edit, the C Scores of the Enriched students increase while the Average students' scored drop. This may be because the writing strategies of the Average writers were less stable, and were therefore easily interfered with by a change in the writing situation. The Enriched writers however, were able to cope with changes in the writing situation, because of their well established executive control structure for writing (M. Scardamalia, personal communication, May, 1986).

The second index which was calculated from the IO Subscale was that of High and Low IO statements (see Table 5). Low IO statements were CN (1-4) + CA (1-4) + CE (1-3, 5 & 6), and High IO statements were CE (4 & 7 - Hypothesizing, and Transforming). Consistent with other findings, these results indicated that the Enriched subjects made the greatest number of high level statements when in the No-edit condition on the computer, while the Average subjects produced their greatest number of High statements in the paper and pencil condition when they were allowed to freely edit. Subjects also generated more content when writing in the condition which was optimal for them in terms of amount of high level statements generated.

Tabulations of the Rereading, Rewording, and Continuing subcategories of the IO scale (CD 5, CR 1, & CD 7) showed that for the Enriched students there was a considerably greater number of these kinds of statements made when working with the computer, particularly in the Edit condition. In the No-edit condition, these numbers were reduced somewhat (see Tables 6, 7 and 8). Among other things, these results demonstrate that consistent with Bereiter & Scardamalia's caution, merely telling

students not to concern themselves with correctness does not necessarily have that much impact. It also shows that in the condition in which the Enriched subjects obtained the highest C Scores (and highest product ratings) they were frequently rewording, rereading, and continuing their texts.

The number of CN 2, CA 2, and CE 2 ("I believe, I think that... etc.) statements were tallied for Average and Enriched subjects, since as previously discussed, such statements may indicate a greater degree of meta-cognition or meta-linguistic awareness. Results indicated that the Enriched students produced twice as many of these kinds of statements as the Average students did (19 vs. 9, see Table 9).

Results for Explicit Operations Subscale

Totals for MC and EO statements were calculated for each subject and these are presented in Table 10. Students generally made few responses which could be scored on the Explicit Operations subscale, and so their scores were not tabulated in detail. Totals for certain subcategories on both the EO and MC subscales were collapsed when there were few coded statements in these subcategories. The total number of Planning (PL), Thinking (PC), and Searching (PH) comments were tallied, and showed that for both the Average and Enriched subjects, more of these procedural statements were generated in the paper and pencil condition, with the greatest number produced when subjects were not editing (see Table 11).

The number of *high level* procedural statements were also calculated. These were comments which were not directed at the content of the text, and so included all planning and thinking statements except PL 1 & 2, and PC 4. (Searching statements were not included in these tabulations because one Average subject made a great deal of these which seemed to inflate the average estimation). These results indicated that the Average students produced their greatest number of high level procedural statements when writing with paper and pencil, while for the Enriched subjects this was only true when they were also in the No-edit condition (see Table 12).

When the planning statements were analyzed separately, the results which emerged proved to be consistent with the previous pattern of findings. High level planning statements were totalled, by adding together all the planning statements which were not directed toward content (see Table 13). The validity of these findings, however, is questionable since differences in performance as a function of experimental conditions comprise at most 2 statements. The Enriched students made more high level planning statements on the whole, than did the Average students (2 vs. 6.5).

Results for Metacomments Subscale

There were a greater number of evaluative metacomments made in both computer conditions by the Enriched subjects, and most of these were of a negative nature (see Table 14). The Enriched students made more than four times as many metacomments directed toward the text (26 vs. 6), and about twice as many directed towards the task (15 vs. 8; see Table 15). Although in general, the Average students made about half as many metacomments as did the Enriched subjects (94 vs. 180), for the Average subjects the number of questions posed, and direct responses made to the experimenter was twice as great as it was for the Enriched subjects (18 vs. 7; see Table 15). The Average students also generated about three times as many statements expressing some kind of block in their thinking, feeling etc. (26 vs. 9; see Table 16).

Discussion

Discussion of the Findings

The results which were revealed by analyses of scores on the Implicit Operations subscale were consistent with previous findings, namely that Enriched students performed best when writing with the computer in the No-edit condition, whereas the Average students performed best when writing with paper and pencil in the Edit condition. For the Enriched students, there may be an optimal level at which increased mechanical concerns actually help to define and to clarify the text, as in the No-edit condition on the computer. This might be because when their attention shifts to a mechanical task, and returns to generating text (which was noted to occur quite frequently -- see Table 8), they may have to reconstruct the theme of their text (as suggested by Scardamalia et al., 1982), and such mental effort may result in the construction of more detailed text representations. Using a word processor may induce more cognitive monitoring (in the form of rereading the text, and making evaluative statements), and low level revision during composing, which can be useful if it is not too extensive. Such cognitive monitoring may encourage more of the recursiveness throughout the writing process, which is characteristic of expert writers. This hypothesis contradicts the view put forth by Gagne (1985), that there is a fixed amount of mental capacity, and that decrements in processing ability will result from distractions in the environment (she gives the example of reduced memory encoding due to the presence of T.V. while studying).

In the condition where they were allowed to edit on the computer, the Enriched students may have been so preoccupied with rereading their text (perhaps due to some kind of mental set, or an overly conscientious attitude), that there was little opportunity for them engage in efforts to construct and reconstruct their texts. It may be that the Average writers were not able to benefit from having to exert more constructive effort, for example, to continually rorient themselves to the text after being interrupted by mechanical concerns, because they did not have a well established set of production strategies which were operative as they attended to various aspects of the task of writing. Since our tests of students' text-editing competence indicated that they were quite poor at the mechanics of editing, it is possible that the average students were distracted by these technical concerns. As Scardamalia, Bereiter & Goelman (1982) suggest however,

> "The important production factor is not memory loss, but rather reconstructive activity that influences the writer's ability to plan at all levels of composition from the lowest levels of mechanics to the highest levels of rhetorical intent. We no longer view attention to mechanics as interfering with higher-level processes. (p. 207)

The Enriched writers appeared to hypothesize, make inferences and transform their texts more frequently than did the Average students. This is what we would expect of knowledge transformers, and it is interesting to note that such strategies can be inferred from the protocols of these young writers, in the absence of many explicit procedural statements.

The findings for the Explicit Operations subscale were consistent with previous findings, in terms of the high level planning statements. However, it appears that there was a fair amount of thinking and searching in other conditions, which did not get transformed into planning. It may be that thinking and searching are rudimentary forms of planning, or that in some cases they actually prevent the writer from developing a plan of action which would facilitate the writing process (in this instance, more is not better). My own sense of some of the protocols of the Average students was that they seemed to go in circles around the same thought, never linking up this mental activity with the writing process. It was as if the *content space* was encapsulated, and was not connected through procedures with the *rhetorical space*. For the Average subjects, the high production of PC statements (thinking, etc.) relative to the other types of procedural statements they make, may be the knowledge teller's equivalent of planning. Because of their lack of goals, they are not able to use these thoughts to alter their text. Thus, their protocols are characterized by quite a number of indirect content statements, with few planning statements. The Enriched students produced slightly more of these PC

statements (18.5 vs. 16.0) but in conjunction with these activities, they were also more able to engage in planning than were the Average students.

The results for the Metacomments subscale indicate that the Enriched subjects were able to reflect on the text and the task, more than the Average subjects were. They also appeared to have engaged in a greater amount of metacognitive and metalinguistic activity, as indicated by the higher number of verbs of propositional attitude (IO subscale). The Average subjects however, generated more metacomments which indicate blocks of some kind, and engaged in more dialogue with the experimenter. This activity could reflect a paucity of active text production strategies which are ongoing through the writing process. The Average students commented on their difficulties and sought assistance from the experimenter, and the latter may reflect a relatively low level of intentional cognition on their part.

Discussion of the C Scale

If we consider for the moment, that the C Score/High Level IO Score on the IO scale reflects the amount of constructive effort expended by the students, then several points can be made. First, such an analysis has shown that the same student can exhibit varying levels of constructive effort depending on the situational constraints. Secondly, it suggests that the C Score is sensitive to changes induced in text processing behavior as a function of experimental constraints. One might suppose that writers will focus more on the construction of meaning in certain situations, and the use of this type of scale might shed some light on which situations are optimal for the performance of different writers. These findings could then be applied to educational settings. Third, this tentative treading into unknown waters seems to indicate that a notion such as constructive effort can viably be explored within the confines of an experimental situation, and that it is instantiated in a task such as writing.

Kirby (personal communciation, March, 1986), has suggested that it may be desirable to have a simple scale which can be used by teachers to score texts, which is not bound by the quality of the text content. Using the Implicit Operations subscale, this was carried out successfully on two texts. In order to make this scale more appropriate for teachers, certain subcategories in the IO subscale could be collapsed, and some categories could be dropped.

As previously discussed, in order to assess levels of constructive effort in young children, it might be useful to devise specific tasks for them which would elicit greater numbers of procedural

statements than they would naturally generate during a writing task. Nevertheless, the present analysis suggests that it is possible to get a sense of varying levels of constructive effort in young writers from analyzing their think aloud protocols, and possibly their texts.

Another application of the C Scale might be for the purposes of examining the ways in which adolescents go about constructing arguments (M. Bryson, personal communication, May 1986). The elements which are scored on the IO subscale comprise those features which have been thought to form the components of arguments, and thus a contextual analysis of the CN, CA, and CE categories might give some indication of the pattern of argument creation.

The C Scale could be used to look for the patterns of different modes of thought (Feldman, 1986). CA 1-3, CN 1-3 and CE 1 -3 may indicate a narrative mode of thought, CA 4, CN 4, and CE 4, a problem solving mode, and CE7, an abstract mode of thought. It may be that similar types of statements form clusters, from which we might infer certain modes of thought to be operative.

Limitations of the Scale

One way the scale should take the quality of content into account is by assessing something like "distance from the gist". At the present time the scale cannot identify content which is generated at a seemingly high level of constructive effort, but which is tangential to the main point and which is not later integrated into the paper.

As all the analyses reported here are preliminary, it remains to be seen whether the findings will stand when interrater reliablity is gathered, and when statistical analyses are performed.

In order to answer questions regarding the transfer of constructive effort from expert to novel domains (to shed light on the issue of the generality of this construct) it is useful to have a scale for assessing constructive effort in areas of expertise, such as writing. The C Scale is suited to writing tasks at the moment. However, the C scale may be appropriate (with some changes) for other tasks in which subjects generate verbal responses while performing tasks in completely novel domains, as for example, while trying to learn a specially designed computer game (that is, designed for the purpose of assessing constructive effort).

C Scale

Content Subscale

CD Miscellaneous

1. **Off topic comments (content)**
2. **Repeating topic anywhere but in the first line of the protocol**
3. **Comments that paraphrase the idea in the topic** ("The topic should be should we have nuclear arms")
4. **Incomplete phrase**
5. **Rereading**
6. **Unscorable** of interrupted content]
7. **Continuation of interrupted content**

CR Reworked Text (can be a search for alternate expressions)

1. **Minor (change in one or two words)** ("invented" becomes "inventions")
2. **Paraphrasing previously stated idea** ("they'll have new inventions" becomes "things that we've just invented")

CN New idea

1. **Personal experience** ("When I was in France...")
2. **Personal belief, opinion, feeling (includes a propositional attitude such as "I believe...", or phrases such as: "I think, I suppose, I know", etc.)** ("Nuclear war doesn't make any sense to me", "I sort of like people who are high up")
3. **General** ("Everybody thinks that computers are gonna be the main thing in the future")
4. **Argument, reason, inference, hypothesis** ("Gaining power might be a reason to have nuclear arms")

CA Addition

1. **Personal experience** ("The second time I was in France...")
2. **Personal belief, opinion, feeling** ("For myself without a T.V. I would be able to spend more time doing homework")
3. **General** ("They would be able to spend more time outside")
4. **Argument, reason, inference, hypothesis** (Same as CN4 except it's an addition to previously generated content)

CE Elaboration

1. **Simple-personal experience**
2. **Simple-personal belief, opinion, feeling**

("I enjoy some of the shows I watch")

3. **Simple-general** ("So as you read and think about all the advantages and disadvantages if a nuclear war is started")
4. **Qualification** ("Although that sometimes helps people to face reality")
5. **Argument, reason, hypothesis, deduction (If...then)** ("They might also not eat as much if there were no T.V.s because they eat in front of the T.V.)
6. **Example** ("An example of this is the soap operas")
7. **Synthesis or transformation** ("We must not think only of ourselves but for everybody")

CO Organization

1. **Comments which organize content** ("The first part is about nuclear war")

Procedural Subscale

(Scored when there is explicit reference to an action or operation)

PD Miscellaneous

1. **Block** ("What should I say next?")
2. **Default** ("I'll say what comes to mind.")
3. **Restart** ("I better start again")
4. **Other - unscorable**

PL Planning (includes *Goals*)

1. **Content - surface** ("I'm going to think of a word that looks better")
2. **Content- meaning, appropriateness** ("I'm going to think of another point")
3. **Organization** (I'll start with some of my own experience")
4. **Gist** ("I think I'll make the main point...")
5. **Rhetorical/Audience** ("I'm going to make this convey a sense of angst")
6. **Procedures - Deciding/clarifying/thinking** ("I'm going to decide what I think about this")
7. **Procedures - Searching/referring to** ("I'll run through my knowledge of this")
8. **Personal** ("I would like to learn what it's like to be a subject in an experiment by doing this task")
9. **Pragmatic** ("I hope to finish this in 20 minutes")
10. **Task-defined** ("I better have something to say into the tape-recorder")

PR Rephrase

1. **Topic**
2. **Text**

PC Deciding/clarifying/thinking

1. **Beliefs** ("I'm just thinking a lot of things would be different")
2. **Procedures** ("I'm thinking about how to continue")
3. **Topic** ("I'm gonna do it with T.V.s")
4. **Content** ("I wonder if the people who have control over these important issues have ever sat back and thought this over")
5. **Rhetorical problem (argument, evidence)** ("I suppose after writing this I can see both sides of the argument")
6. **Gist** ("I'm just thinking about how to include that idea in this paper")

PH Searching/Referring to:

1. **Personal experience** ("I remember doing something like that")
2. **Personal beliefs, opinions, feelings** (Let me just remember what I believe about that")
3. **General knowledge** ("I know something about cars")
4. **Discourse knowledge - surface** ("I need a new paragraph")

5. **Discourse knowledge - deep** ("I better think of a conclusion") or genre-related
6. **Procedural knowledge** ("I think I know how to approach this task")

PS Self-probes

1. **Content** ("What does university education hold for us?)
2. **Beliefs** ("Should we have nuclear arms?)
3. **Procedures** ("What should I do now?)
4. **Text - surface** ("Is that spelled right?")
5. **Text - structural** ("Does that idea fit in?")
6. **Text - meaning** ("Does that idea make sense?")
7. **Rhetorical/Audience** ("Will that make sense when someone reads it?")

PT Translating

1. **Trying to put ideas into words** ("I sort of know, but I don't know how to put it inot words")
2. **Transposing general ideas to specific ones** ("I'll relate these ideas to the topic")
3. **Transposing specific ideas to more general concepts** ("I think I'll talk about the larger issue of learning")

PV Reviewing

1. **Rereading** ("I'll reread what I've written" or "I am rereading...")
2. **Organizing/summarizing** ("So that has to do with the second part")

Metacognitive/Evaluation Subscale

MD Miscellaneous

1. **Direct response/question to experimenter** (In response to "what kinds of things are you thinking about subject says "I don't know really")
2. **Miscellaneous** ("Let's see")
3. **Block - content** ("I don't know what to say")
4. **Block - subjective** ("I don't know what I think/feel")
5. **Block - procedure** ("I don't know what to do")
6. **Other - unscorable**

MB Beliefs

1. **Topic** ("This is an interesting topic")
2. **Beliefs** ("That idea makes sense")

MT Text (The following will be assigned 2 additional values: S/O for Self, or Other oriented comments; and a "+/-" to indicate whether the comment is a positive, or negative one)

1. **Word - surface** ("That word is spelled wrong")
2. **Word - deep** ("I don't think that's the right word")
3. **Word - unspecified** ("I don't like that word)
4. **Sentence - surface** " "
5. **Sentence - deep** " "
6. **Sentence - unspecified** " "
7. **Global - surface** (Ugh, that doesn't look right)
8. **Global - deep** ("This paper makes a lot of sense")
9. **Global - unspecified** ("It's all a blur")

MK Task (Also assigned a positive or negative +/-.)

1. **Specific** ("I've only done half a page")
2. **General** ("This task is boring")
3. **Constraints** ("My paper's gonna be too long")
4. **Mode** ("I hate writing with computers")
5. **Think-aloud** ("Should I say something?")
6. **Insightful, conceptual** ("This was a good opportunity for me to clarify my thoughts about...")

MP Procedures (Also assigned a positive or negative rating)

1. **Specific - Gist related** ("I better get back to the main point")
2. **Specific - Other procedures (can be any on P scale)**
3. **General** ("When I write I usually")

MS Self (Also assigned a positive or negative rating)

1. **Positive** ("Right, I feel okay now")
2. **Negative** ("Feels strange")
3. **Neutral** ("Where am I?")

ME Evaluation - other

1. **Comments like "No", "Oops" (not scored if it forms part of a larger**

evaluative statement) (Yeah, okay, ugh, oops, no)

2. **Revision** ("I'm going to edit that")
3. **Deferring evaluation/revision** ("I'll edit that later")
4. **Ignore evaluation** ("I'll just leave it as it is")

MJ Subjectivity (Also assigned a positive, negative, or neutral rating)

1. **Effort** ("I don't like the topic but I"ll try hard anyway")
2. **Intention** ("That's what I want to do" or "what I wanted to do")
3. **Sense of difficulty** ("This is hard")

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Tables of Results

TABLE 1 - 10 SCALE TOTALS (For each subject)

	AVERAGE																	
	COMPUTER				PAPER + PENCIL				ENRICHED									
									COMPUTER				PAPER + PENCIL					
	A_3		A_4		A_{11}		A_{12}		Σ_3		Σ_4		Σ_{11}		Σ_{12}			
	Edit	NE.	Edit	NE	Edit	NE	Edit	NE	Edit	NE	Edit	NE.	Edit	NE	Edit	NE.		
CD 1				1	1			9	1									
2				8														
3		1	1	1	1	2												
4			1							2	1							
5		1	5	3		2	2	17	2	1	5	2	1	5			2	
7	10	2	4	5	1	4	2	20	58	27	39	34	6	7	6	8		
CA 1				4	2	1		7	23	12	32	33	8	2	1	5		
2	2	1	1					2	11	12	16	9	6	3	4	7		
CN 1									1	1					2			
2	2							2	1		1	1						
3																		
4	1	1		1				2					1					
CA 1																		
2				2		3	1		1	1	1	1						
3					6			1	3	2	3	1		2	1			
4	1	3	4	1														
CE 1						1	2				3		3	1	1			
2			1							3								
3						1	2				2	10	5	4	2	1		
4	1		4	1	4	2	4	2					1	1		2		
5					4			1	1		1							
6				2									2	1		1		
7	1																	
C 1-3	8	1	3	11	8	10	10	5	16	11	11	9	9	11	8	8		
C 4-7	4	4	8	5	14	2	4	6	4	5	7	12	9	6	2	5		

TABLE 2 – C SCORES FOR EACH SUBJECT ON IO SCALE

AVERAGE

		WEIGHT #	COMPUTER A_3 Edit	COMPUTER A_3 NE.	COMPUTER A_4 Edit	COMPUTER A_4 NE.	PAPER + PENCIL A_{11} Edit	PAPER + PENCIL A_{11} NE.	PAPER + PENCIL A_{12} Edit	PAPER + PENCIL A_{12} NE.
CN+CA	1-3	1	7 = 7	1 = 1	0 = 0	11 = 11	8 = 8	6 = 6	5 = 5	4 = 4
CE	1-3	2	1 = 1	0 = 0	3 = 6	0 = 0	0 = 0	4 = 8	5 = 10	1 = 2
CN+CA	4	3	2 = 6	4 = 12	4 = 12	2 = 6	6 = 18	0 = 0	0 = 0	1 = 3
CE	5,6	3	0 = 0	0 = 0	0 = 0	2 = 6	4 = 12	0 = 0	0 = 0	1 = 3
CE	7.7	10	2 = 20	0 = 0	4 = 40	1 = 10	4 = 40	2 = 20	4 = 40	2 = 20
			T = 34	T = 13	T = 58	T = 33	T = 78	T = 34	T = 24	T = 34
			N = 12	N = 5	N = 11	N = 16	N = 22	N = 12	N = 14	N = 7
			C = 3.4	C = 1.3	C = 5.8	C = 3.3	C = 7.8	C = 3.4	C = 5.5	C = 3.4

ENRICHED

		WEIGHT #	Computer E_3 E	Computer E_3 NE	Computer E_4 E	Computer E_4 NE	P+P E_{11} E	P+P E_{11} NE	P+P E_{12} E	P+P E_{12} NE
CN+CA	1-3	1	9 = 9	4 = 4	6 = 6	3 = 3	3 = 3	7 = 7	3 = 3	7 = 7
CE	1-3	2	7 = 14	7 = 14	5 = 10	6 = 12	6 = 12	4 = 8	5 = 10	1 = 2
CN+CA	4	3	3 = 9	2 = 6	3 = 12	1 = 4	1 = 3	0 = 0	2 = 6	0 = 0
CE	5,6	3	1 = 3	0 = 0	1 = 3	0 = 0	1 = 3	1 = 3	0 = 0	3 = 9
CE	4.7	10	0 = 0	3 = 30	1 = 10	11 = 110	7 = 70	5 = 50	2 = 20	2 = 20
			T = 35	T = 54	T = 91	T = 131	T = 91	T = 62	T = 37	T = 35
			N = 20	N = 16	N = 16	N = 21	N = 18	N = 17	N = 10	N = 13
			C = 3.5	C = 5.4	C = 4.1	C = 12.9	C = 9.1	C = 6.2	C = 3.7	C = 3.8

TABLE 3

C Scores for Implicit Operations Subscale

AVERAGE

	EDIT	NO-EDIT
Computer	4.6	2.3
P & P	6.7	3.4

ENRICHED

	EDIT	NO-EDIT
Computer	3.8	9.2
P & P	6.2	5.0

Overall Average C Scores for Implicit Operations:

Enriched = 6.05
Average = 4.25

EDITING

	Edit	No-edit
Average	5.7	2.9
Enriched	5.0	7.1

MODE

	Edit	No-edit
Average	5.1	3.5
Enriched	5.6	6.5

TABLE 4

AVERAGE

	Edit	No-edit
Computer		
P & P	X	

ENRICHED

	Edit	No-edit
Computer		X
P & P		

TABLE 5

Average High/Total Statements on the Implicit Operation Subscale (High = CE4, CE7)

AVERAGE

	Edit	No-edit
Computer	High 3.0 Total 11.5	High .5 Total 10.5
P & P	High 4.0 Total 18.0	High 2.0 Total 10.5

Total high = 9.5

Total content=50.5

ENRICHED

	Edit	No-edit
Computer	High 1.5 Total 18.0	High 7.0 Total 18.5
P & P	High 4.5 Total 14.0	High 3.5 Total 15.0

Total high = 16.5

Total content= 65.5

TABLE 6

Average Number of Incidences of Rereading Text

AVERAGE

	Edit	No-edit
Computer	3.5	2.0
P & P	1.0	9.5

ENRICHED

	Edit	No-edit
Computer	48.5	30.5
P & P	6.0	7.5

TABLE 7

Average Number of Incidences of Rewording the Text at a Surface Level

AVERAGE

	Edit	No-edit
Computer	0	2.0
P & P	1.0	4.0

ENRICHED

	Edit	No-edit
Computer	13.5	10.5
P & P	5.0	5.0

TABLE 8

Average Number of Continuations (CD7)

AVERAGE

	Edit	No-edit
Computer	7.0	3.5
P & P	1.5	12.0

ENRICHED

	Edit	No-edit
Computer	27.5	22.5
P & P	4.5	3.5

TABLE 9

Use of Verbs of Propositional Attitude (CN2 & CA2 & CE2)
("I think..","I believe.." etc.)

AVERAGE: $\frac{9}{101} \frac{(CN2 \;\&\; CA2 \;\&\; CE2)}{(CN \;\&\; CA \;\&\; CE)}$ = 9% (of total content)

ENRICHED: $\frac{19}{131} \frac{(CN2 \;\&\; CA2 \;\&\; CE2)}{(CN \;\&\; CA \;\&\; CE)}$ = 15% (of total content)

TABLE 10 - TOTALS FOR EXPLICIT OPERATIONS SUBSCALE

	AVERAGE								ENRICHED							
	COMPUTER				PAPER + PENCIL				COMPUTER				PAPER + PENCIL			
	A_3		A_4		A_{11}		A_{12}		E_3		E_4		E_{11}		E_{12}	
	Edit	NE.	Edit	NE	Edit	NE	Edit	NE	Edit	NE	Edit	NE.	Edit	NE	Edit	NE.
PD 1																
2																
3																
PL 1											1					
2					1						1					
3											1					
4	2				1	1	1		2	3	1	2			3	
5																
6																
7																
8																
9																
10																
PA 1																
2																
PC 1					1	1	1									
2	2				1				1	1	1					
3					2	1	1	3		1					1	
4					4	1	1	2		1		2			4	
5								1								
6		1														
PH 1						1		1								
2							1	4							3	
3												1				
4								1			1	1				
5						1										
6							1									
PS 1											1					
2																
3											1					
4																
5											1					
6																
7											1					
8																
PT 1							1									
2					1											
3																
PV 1																
2																

TABLE 10 cont.'d - TOTALS FOR METACOMMENTS SUBSCALE

	COMPUTER				PAPER + PENCIL				COMPUTER				PAPER + PENCIL			
	A_3		A_4		A_{11}		A_{12}		Z_3		Z_4		Z_{11}		Z_{12}	
	Edit	NE.	Edit	NE	Edit	NE	Edit	NE	Edit	NE	Edit	NE.	Edit	NE	Edit	NE.
MD 1			1	1	5	2	8	7		1	8	4	4			
2	1															
3		1			3	3	1						1	2		
4	1	1			5	2		4			3		2			
5						1		1						1		
6					2									1		
MB 1					1	1										
2								1								
MT 1								1		2	8	2			1	
2									1							
3													1			
4																
5														1		
6											1					
7													2			
8												1		1		
9											4	1				
10	5													1	1	1
MK 1					1						1					
2								1			1					
3					1			1			1	1	1	1		
4	1		1	2							6					
5											1					
6																
								1						1		
MP 1								1								
3																
MS 1																
2								1			1		1			
3									1	1						
ME 1	13		4		1	2		1	8	2	41	35	6	1		
2											1					
3											1	1		1		
4												1				
MJ 1					2						1					
2								2						2		
3		1		1	1								2	1		

TABLE 11

Average Total Planning, Thinking and Searching Statements (PL, PC, PH)

AVERAGE

	Edit	No-edit
Computer	2.5	.5
P & P	8.0	17.0

ENRICHED

	Edit	No-edit
Computer	3.5	6.5
P & P	7.0	12.0

TABLE 12

Average High Level Planning and Thinking Statements to Total Planning and Thinking Statements (PL 3-10, PC 1-3, 5 & 6)

AVERAGE

	Edit	No-edit
Computer	High 2 / Total 2.5	High .5 / Total .5
P & P	High 4 / Total 7.5	High 4 / Total 8

Total High = 10.5
Total = 18.5

ENRICHED

	Edit	No-edit
Computer	High 3 / Total 4	High 3.5 / Total 5
P & P	High 3.5 / Total 7	High 7 / Total 10

Total High = 17
Total = 26

TABLE 13

Average Number of High Level and Total Planning Statements

AVERAGE

	Edit	No-edit
Computer	High 1 / Total 1	High 0 / Total 0
P & P	High 1 / Total 1.5	High 0 / Total .5

ENRICHED

	Edit	No-edit
Computer	High 2 / Total 3	High 2.5 / Total 2.5
P & P	High 1.5 / Total 1.5	High .5 / Total .5

TABLE 14

Average Number of Evaluative Metastatements (directed towards the task and text)

AVERAGE

	Edit	No-edit
Computer	12.0	1.0
P & P	1.5	3 0

ENRICHED

	Edit	No-edit
Computer	35.5	22.0
P & P	6.0	3.0

TABLE 15

Metastatements

Directed Towards the Text (MT 1-10)

Average - $\frac{6}{94}$ (Text directed comments) (Total Metastatements) = 6%

Enriched - $\frac{26}{180}$ = 14%

Directed Towards the Task (MK 1-6)

Average - $\frac{8}{94}$ (Task directed comments) (Total Metastatements) = 9%

Enriched - $\frac{15}{180}$ = 8%

Questions or Direct Responses to Experimenter: (MD1)

Average - $\frac{18}{94}$ (Experimenter Oriented) (Total Metastatements) = 19%

Enriched - $\frac{7}{180}$ = 4%

TABLE 16

Blocks (MD3-6)

Average - $\frac{26}{94}$ (Comments indicating a block) (Total Metastatements) = 28%

Enriched $\frac{9}{180}$ = 5%